0.033), larger minimal joint space (p<0.001), and superior self-reported WOMAC function ($p = 0.019$) and stiffness ($p = 0.019$). During gait, the non-operated patients had larger hip- and knee joint excursion and a larger hip flexion moment during the latter 50% of stance (p-values 0.003 to 0.015). No differences were found from baseline to follow-up in gait characteristics, minimal joint space, 6-meter walk test, or overall function at the 6-7 year follow-up of the non-operated patients. Self-reported pain assessed from the WOMAC was significantly improved ($p = 0.024$).

Conclusions: Even if all patients were classified as having mild to moderate symptoms at inclusion, we found significant baseline differences both in gait and function between the patients who later underwent total hip replacement and those who were still non-operated at the 6-7 year follow-up. The non-operated patients revealed no signs of disease progression at follow-up. Joint excursion and moments were maintained, and neither the minimal joint space, 6-meter walk test, overall hip range of motion, or self-reported WOMAC function, stiffness or pain deteriorated.

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KNEE JOINT STIFFNESS AND ITS RELATIONSHIP WITH SEVERITY OF RADIOGRAPHIC OSTEOARTHRITIS, PAIN AND SELF-REPORTED STIFFNESS

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Purpose: Joint stiffness is a common symptom of knee osteoarthritis (OA) but often only evaluated using self-reported questionnaires. The passive pendulum test is a biomechanical laboratory test that has been used to measure the stiffness and damping co-efficients in the knee which are related to the biomechanical properties of the tissues making up the joint. The aims of this study were to [1] determine if stiffness and damping co-efficients differ between persons with normal knees (controls), knee pain (KP), radiographic knee OA (ROA) and symptomatic knee OA (SOA); [2] examine the relationships between radiographic severity, pain severity, self-reported stiffness and the lab based measures, and [3] explore how anthropometric measures, pain severity, and radiographic variables contribute to the overall variance of the biomechanically assessed stiffness co-efficient.

Methods: 243 community participants were recruited and divided into 4 groups based on the presence or absence of moderate knee pain and ROA ($\geq$ grade 2 Kellgren & Lawrence). Stiffness and damping co-efficients were derived from the angular motion of the knee during the passive pendulum test using a motion analysis system (Coda). X-rays were graded using the Nottingham Logically derived Line Drawing Atlas. A 100 mm VAS was used to assess pain severity and the Western Ontario and MacMasters Osteoarthritis Index was used to assess self-reported pain, stiffness and function.

Results: 243 participants were recruited with 157 (65%) women and 86 (35%) men. Mean age was 70.3 years (SD 8.9). 90 participants had normal pain-free knees, 59 had KP only, 32 had ROA and 62 had SOA. Over a third of participants (89) were unable to successfully perform the passive pendulum test. The reliability of the test in those who could perform it was high (ICC = 0.85 95% CI (0.52 – 0.96) for damping co-efficient and ICC = 0.96 95% CI (0.85-0.99) for stiffness co-efficient).

The mean stiffness co-efficient was significantly higher in the SOA group compared to controls (mean difference = 2.91 Nm/rad $p = 0.04$) but not between other groups. We found no significant differences between groups for the mean damping co-efficient. A weak correlation was observed between radiographic severity and the stiffness co-efficient ($r = 0.19$, $p = 0.2$). Pain severity using the VAS and WOMAC scores showed positive correlations with the stiffness co-efficient ($r = 0.3$, $p<0.01$ and $r = 0.2$, $p<0.01$ respectively) but not with damping co-efficients. WOMAC stiffness was correlated with stiffness co-efficients ($r = 0.3$, $p<0.01$) and was stronger when examined in those participants with SOA ($r = 0.4$, $p<0.01$). We also found that WOMAC stiffness was strongly correlated with pain VAS scores ($r = 0.80$, $p<0.01$).

A multiple regression was run to predict stiffness co-efficients from age, gender, body mass index (BMI) pain VAS, radiographic scores and WOMAC stiffness scores ($F(6,147) = 58.2$, $p<0.001$, R2 = .0.70) but only gender and BMI were significantly associated ($p<0.001$).

Conclusions: Stiffness co-efficients were significantly higher in those with SOA compared to those with normal knees and showed modest correlations with radiographic severity, pain severity and self-reported stiffness. Consistent with previous research we found that BMI and gender were significant predictors of stiffness co-efficients but that additional variance could not be explained by radiographic or pain severity or by self-reported stiffness. Further research is needed to consider the validity of the passive pendulum test, particularly in older persons who may find it difficult to perform. The lack of association between the biomechanical co-efficients and radiographic severity suggests that other neuro-muscular variables may have a greater role to play in biomechanically assessed joint stiffness.

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CENTER OF PLANTAR PRESSURE CAN PREDICT CHANGES IN TIBIOFEMORAL CONTACT LOAD

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Purpose: Biomechanical treatments for individuals with medial compartment knee osteoarthritis (OA) often target the knee adduction moment (KAM). The peak KAM, which has been implicated in both OA severity [1] and progression [2], is altered during walking using shoe adaptations or gait modifications such as “medial thrust” gait;[3] however, individuals vary in their load response. Successful KAM reductions are frequently attributed to shifts in center of plantar pressures (COP) although a clear relationship between knee loads and foot pressure has not been demonstrated. Establishing such a relationship would profoundly increase the biomechanical treatment options for OA. Therefore, the aim of this cross-sectional study is to determine if COP is consistently medialized when peak KAM is reduced. Since other moments can contribute to increase or decrease knee loading, the sagittal and transverse planes were investigated as well. A definitive relationship of COP with KAM would support the use of pressure distribution as an indirect marker of load across the tibiofemoral joint (TFJ).

Methods: 16 healthy subjects (26.9 $\pm$ years, 9M,7F) completed 5 barefoot walking trials each of normal gait and medial thrust gait. Left leg data were analyzed and reported. Lower limb kinematics were obtained using 12 optoelectric cameras (Qualysis, Gothenberg, Sweden) and 28 reflective markers on bony landmarks. For simultaneous COP and 3-D ground reaction force acquisition, a pressure platform (Emed, Novel, Munich, Germany) was mounted onto a force plate (Bertec, Columbus, OH) and the stacked assembly was leveled with the walkway. All capture systems were run at 100 Hz to allow for accurate synchronization of stance phase, knee moments, and plantar pressures. COP was quantified by determining the Medial to Lateral Pressure Index (MLPI) (Figure 1). Differences in COP between normal and thrust gait were calculated and compared to the corresponding changes in KAM, sagittal and transverse plane moments. Pearson Correlation and linear regression analysis were used to compare the change in each peak KAM and the corresponding change in MLPI.

Results: During the first half of stance, a shift in of COP was highly correlated with a change in first peak KAM (Table 1, Figure 2). COP and KAM demonstrated a lower but significant correlation during the 2nd half of stance. The flexion moment was the only other moment which correlated with MLPI (Table 1). A change of MLPI during each half of stance was best predicted by the corresponding peak KAM; adding knee flexion moment walking speed, gender, and age did not enter the forward regression model, although speed influenced the 2nd peak KAM ($r = 0.579$, $p = 0.019$).

Conclusions: This study establishes that plantar pressure measurements can be used to indirectly assess the response in load distribution across the TFJ with medial thrust gait. 100% of subjects who medialized their plantar pressures in the first half of stance also reduced their first peak KAM. Both sagittal and transverse plane moments increased with medial thrust walking which may diminish the therapeutic benefits from a reduced KAM, however the impact of these moments on the progression of medial compartment OA is not well established. While these findings have been derived from medial thrust gait, further testing with other gait retraining methods and biomechanical interventions that do not directly interfere with a shoe-pressure detecting insole-foot interface should yield similar results. As such, a cost-effective pressure detection device may be suitable for detecting change in load across the TFJ as a result of a biomechanical gait intervention.

Table 1
Pearson Correlation Coefficients comparing Medial/Lateral Pressure Index in early stance with external moments at the knee joint and speed

	First peak KAM	Second peak KAM	Flexion moment	Extension moment	External rotation moment	Internal rotation moment	Speed
Early stance pressure index	**0.827*****	**0.570***	**-0.675****	-0.365	-0.473	-0.332	0.209
Late stance pressure index	0.119	**0.538***	-0.296	-0.492	-0.119	-0.426	0.246

*= significant correlation (p<.05), **= significant correlation (p<.01), *** = significant correlation (p<.001).

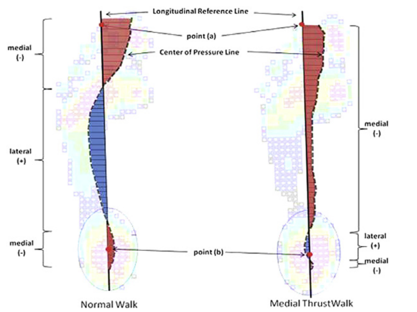

Figure 1. Medial-Lateral Pressure Index: Distances form each data point on the Center of Pressure Line (COP) to the Longitudinal Reference Line (LRL) were summed, with COP data points lateral to the LRL positive and those medial to the LRL line negative. In this example, the Normal Walk had roughly equal lateral and medial COP data points resulting in a MLPI near 0.0mm, while the Medial Thrust Walk resulted in most COP data points positioned medial to the LRL, resulting in a MLPI near -40mm.

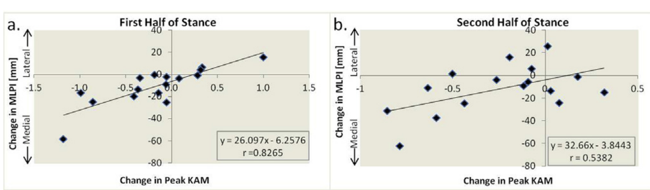

Figure 2. Peak KAM versus Pressure. 2a: The change in first peak knee adduction moment (KAM) versus the corresponding change in medial-lateral pressure index (MLPI) between normal and medical thrust gait. Figure 2b: The change in second peak KAM versus the corresponding change in MLPI.

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EFFECTS OF MEDIAL OPENING WEDGE HIGH TIBIAL OSTEOTOMY ON MOMENTS ABOUT THE KNEE DURING WALKING AND STAIR CLIMBING

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Purpose: To compare knee joint moments in frontal, sagittal and transverse planes during level walking and during stair ascent before, 6 and 12 months after medial opening wedge high tibial osteotomy (HTO) surgery.
Methods: Fourteen patients (Age: 46 ± 6.8 years, BMI: 28.7 ± 3.7 kg/m^2) with varus alignment and osteoarthritis primarily affecting the medial compartment of the tibiofemoral joint participated. Three-dimensional motion analysis during level walking and stair ascent was evaluated before surgery, and 6 and 12 months after medial opening wedge HTO. For both level walking and stair ascent, the peak knee adduction, flexion, extension, internal and external rotation moments were calculated from the mean of five trials using inverse dynamics. Each measure was compared before and after surgery using a two-factor, ambulation condition (walking vs. stair ascent) by time (before HTO, 6, 12 months after HTO) analysis of variance with Scheffe post-hoc tests following any significant main effects or interactions.
Results: Ensemble averages for the moments about the knee during 100% of stance for walking and stair ascent before and after HTO are illustrated in Figure 1. Mean peak values with 95% confidence interval (CIs) are also shown in Figure 1. There were significant main effects for both the type of ambulation (p<0.01) and for time (p<0.05) for the peak knee adduction, flexion and internal rotation moments. For the peak extension moment, there was a significant main effect for ambulation (p = 0.03), but not for time (p = 0.31). There were no significant effects on the peak external rotation moment (p > 0.1). There were no significant interactions for all moments (p > 0.19). The peak knee adduction (p = 0.001) and extension moments (p = 0.028) were significantly lower during stair ascent than level walking, while the peak knee flexion (p<0.01) and internal rotation moments (p = 0.003) were higher (pre and postoperatively). The peak knee adduction, flexion and internal rotation moments were all significantly lower at 6 months after HTO during walking and stair ascent (p<0.05), and did not change at 12 months postoperative (p > 0.3). The mean overall change (95% CI) was 1.71 %BW*Ht (1.35-2.06) and 1.35 %BW*Ht (0.80-1.90) for the peak knee adduction moment, 0.51 %BW*Ht (0.07-0.96) and 0.12 %BW*Ht(-0.72-0.97) for the peak knee flexion moment, and 0.55 %BW*Ht (0.68-0.43) and 0.50 %BW*Ht (0.64-0.36) for the peak knee internal rotation moment, during walking and stair ascent, respectively.
Conclusions: Medial opening wedge HTO results in substantial changes in the external moments about the knee in each of the frontal (46%), and transverse (43%) planes, during both level walking and stair ascent.

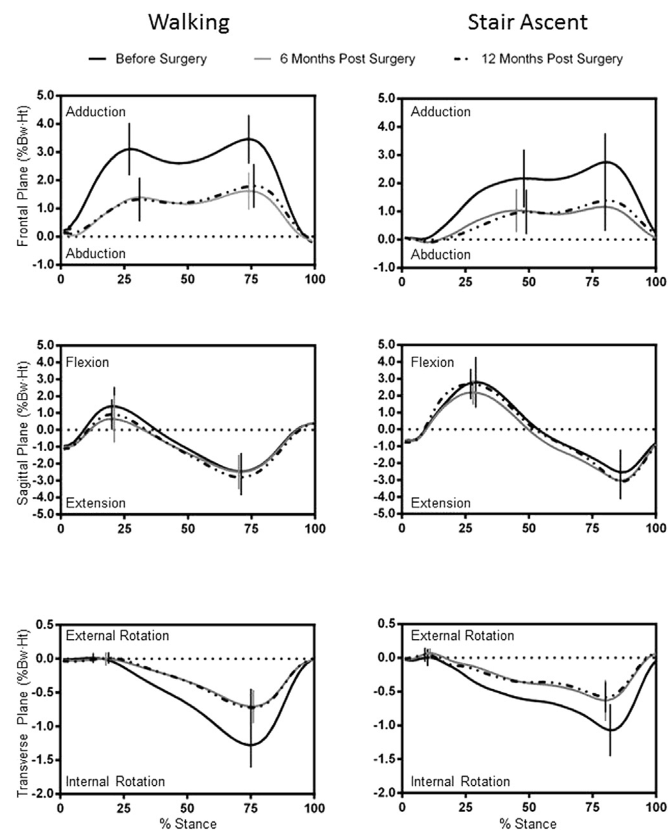

Figure 1. Knee moment ensemble averages (n = 14). Vertical bars represent 95% CIs for peak values.

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CLINICAL IMPAIRMENTS UNDERLYING ABNORMAL FRONTAL PLANE BIOMECHANICS IN PERSONS WITH END-STAGE HIP OSTEOARTHRITIS

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Purpose: Changes in frontal plane trunk and pelvic mechanics are often described as consequences of hip pain and weakness in persons with hip OA. The purpose of this study was to identify interlimb differences in pelvic and trunk biomechanics in persons scheduled for unilateral